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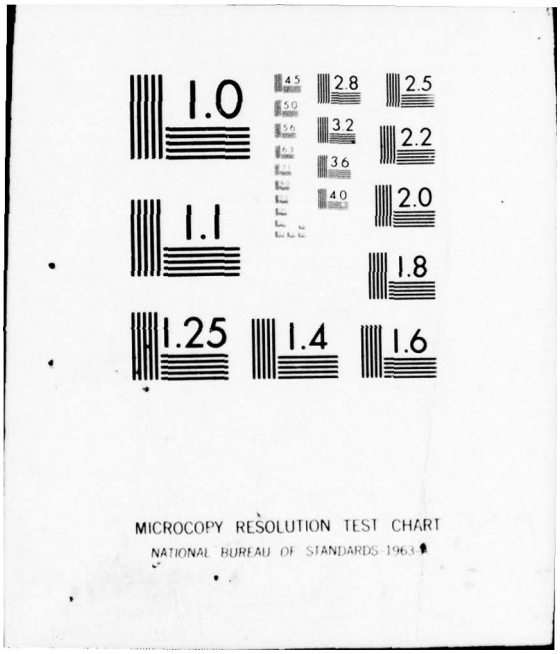
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General Diffraction and Scattering 1972-1974 (Excluding High Frequency Techniques, Transient Electromagnetics and Numerical Methods)

Prepared for International Commission VI, URSI
Triennial Report
by
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Abstract:

The world's published research on general diffraction and scattering for the period 1972-1974 is reviewed as a part of the Triennial Report of International Commission VI, International Scientific Radio Union (URSI).

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Interdisciplinary Interaction:

A few years ago, Mark Kac (1972) observed hopefully that physics and mathematics, then in a period of alienation were showing signs of a rapprochement. Activity in the area of General Diffraction and Scattering during the period 1972-1974 appears to support this optimistic view and increase the circle of rapprochees to include radio engineering.

Perhaps the most significant area of contact concerns the application to obstacle scattering problems of methods developed in quantum mechanical scattering. A detailed review of approximate methods in potential and particle scattering, including methods which have not yet been applied in electromagnetic scattering as well as those which have, was presented by Joachim and Quigg (1974). Methods which have found application in electromagnetics in this period include the use of symmetry groups (Barnt et al,1973) WKB methods (Chakraborty, 1973), and a Volterra integral equation technique for solving the Lippman-Schwinger equation (Kouri, 1973).

The infusion of ideas developed in other disciplines also included applications of the extinction theorem in molecular optics (Pattanayak and Wolf, 1972), (Wolf, 1973) and analogies with elasticity (Peng, 1973). The method of matched asymptotic

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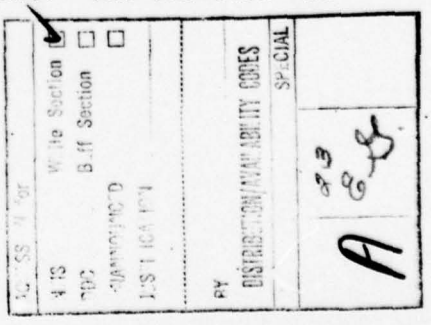
expansions and singular perturbations were applied to acoustic scattering (Lesser and Lewis, 1972a,b,1974) and variational methods found continued application in both acoustics and electromagnetics (Coen and Wexler, 1973) (Foster and Andersen, 1973). (Hazel and Wexler, 1972) (Kulikov, 1973) (Voytovich et al,1972). Reviews of acoustic diffraction theory were presented by Jones (1972) and Horton (1972) and an extensive bibliography of acoustic scattering was assembled by White and Sonn (1972).

Integral equation formulations have provided the basis for most of the analytical as well as numerical work in this period and underlie many of the investigations included here under other headings. Not mentioned elsewhere, however, is the work on Fredholm equations of the first kind of Belward (1974) and Kravtsov and Shatov (1973), Bojarski's (1972) K-space formulation of electromagnetic scattering, deJong's (1972a) for mulation of piezoelectric diffraction problems, the surface integral equation formulations of Fawzi (1974) and Gruner et al (1974), and the treatment of far zone scattering given by Kul'ko and Mikhnova (1972).

Eigenvalues and Modal Expansions:

Because of the equivalence of the complex eigenvalues (decay rates) of the exterior problem and the poles of the resolvent in the integral equation formulation of the scattering problem, considerable understanding has been gained of the intimate connection between the transient problem whose solution may be represented in terms of the corresponding exterior eigenfunctions and the time harmonic problem whose solution may be represented in terms of the resolvent. The location and



scattering geometry dependence of these poles will undoubtedly be the objects of research efforts for some time but considerable progress has been made in this period by Arsenev (1972), Beale (1973), Daboul and Jensen (1973), Goldstein (1974), Gulicher and Krasnushkin (1972), Lax and Phillips (1972a,b), Majda (1974), Marin and Latham (1972), Marin (1973, 1974a), Morawetz (1972), Ramm (1972), Shenk and Thoe (1972), Tesche (1973a,b) and Valnberg (1972). The use of characteristic modes directly in electromagnetic scattering problems was treated by Harrington et al (1972), Nikol'skiy and Feoktistov (1972), Ramm (1973) and Zaboronkova and Kondrat'ev (1972).

Problems associated with eigenvalues of interior problems and their relevance to exterior scattering were also examined (Bolomey and Tabbara, 1973) (Jones, 1974) (Kleinman and Roach, 1974) (Leis, 1974) (Rogers, 1973b) (Shamma and Karp, 1972) (Tai and Shaw, 1974) (Ursell, 1973) and (Wirgin, 1973a).

Application of more general modes, not necessarily eigenfunctions associated with a particular scatterer, was made by Harrington and Mautz (1972a) and Mautz and Harrington (1973). The use of spherical harmonics in problems involving nonspherical scatterers, as exemplified in the "extended boundary condition" method (Waterman, 1971), continued to receive attention (Bates and Wong, 1973, 1974) (Bolomey and Wirgin, 1974) (Devaney and Wolf, 1973, 1974) (Eyges, 1973) (Hizal, 1973, 1974) (Hizal and Tosun, 1973) (Peterson and Ström, 1973, 1974a,b) (Ström, 1974). Reilly (1973) also used spherical harmonics for nonspherical scatterers but, in contrast to the above, did not assume convergence on the surface but matched coefficients on the smallest enclosing sphere. The question of convergence of expansions in spherical harmonics on nonspherical surfaces has apparently been resolved (Millar, 1973a) and conditions for the validity of expansions in terms of outgoing waves only, the Rayleigh criteria, have been provided (Bates et al, 1973) (Ikuno and Yasuura, 1973)

(Kozachek and Sachemko, 1974) (Landsberg, 1973) (Millar, 1973b). Related work took place on problems involving radiation conditions (Naylor, 1972) (Naylor et al, 1923) (Roach and Adams, 1972).

Gratings:

Use of the Rayleigh criteria in single body scattering does not mean that grating problems, which fostered a flourishing controversy over its validity, have been ignored. In addition to a review of grating problems (Petit and Maystre, 1972a) and the aforementioned work of Millar (1973a) on Rayleigh criteria, results have been obtained on sinusoidal gratings (Dailami et al, 1972) (Fang, 1972), Echelette gratings (Jovicevic and Sesnic, 1972), imperfectly as well as perfectly conducting gratings (Maystre, 1972, 1973) (Maystre and Petit, 1972b) (Neviere et al, 1973), double gratings (Blok and Mur, 1972) (Butenko and Litvinenko, 1972) gratings separating different media (Kitajuna, 1972) (Adonina et al, 1972) and gratings of strips (Kent and Lee, 1972), cylinders (Bezuglyi and Shestapalov, 1973), dielectric cylinders (Barkley et al, 1973), dielectric bars (Masalov and Repa, 1972) and cylinders of arbitrary cross section (Astapenko, 1972) (van den Berg and Voorman, 1972). The closely related problem of scattering by periodic arrays was also considered (Litvinenko and Oblyvach, 1972) (Kasanskii et al, 1974) (Kirilenko and Masalov, 1972a,b) (Solymer and Appel-Hansen, 1974) and arrays of wires also received attention (Otteni, 1973) (Wait 1972a,b) (Wilson, 1974).

Low Frequency Scattering:

An integral equation method was developed in scalar scattering which yields the unknown surface field as the limit of interates of a surface integral operator for a wide class of scatterer geometry (Ahner and Kleinman, 1973). Extensions to piecewise homogeneous media were derived (Ahner, 1974) and a related formulation

in electromagnetics was discussed (Ormsby, 1974). Although limited to low frequencies, the technique differs essentially from standard low frequency expansions in that it apparently has a larger radius of convergence. Totally independent integral equation methods were developed to solve the two dimensional problem for cylinders of arbitrary cross section using conformal mapping by Hill et al, (1973) and Shafai, (1973a).

In the area of low frequency expansions, a method was derived for utilizing polarizability tensors which are independent of the incident field to determine the first (dipole) term in a Rayleigh series representation of the electromagnetic field scattered by a perfect conductor (Keller et al, 1972) (Kleinman and Senior, 1972) (Kleinman, 1973). Corresponding results in acoustic scattering were obtained by Senior (1973). Similar results in scattering by small apertures were derived by Fikhnanas and Fridberg (1973a,b), Stepanyuk et al (1973) and van Bladel (1972). A circuit parameter interpretation of the first two terms in an expansion of the field scattered by small dielectric objects was given by van Bladel (1973) and the anistropic case was considered by De Mey (1974).

Low frequency scattering results for particular configurations were obtained by Hill and Wait (1972,1973,1974) for spheres near the ground, cylinders and spheroids and by Love (1974) for a torus. Determination of the first (dipole) term is essentially an electrostatic potential problem and relevent results were obtained by Beluga (1972) for cylinders of arbitrary cross section, Fikioris (1973) for spheroids and Murashima (1973) for finite cylinders. Variational methods in electrostatics were treated by Kulikov (1972) and Kulikov and Levina (1972)

while the applications of probabilistic potential theory were discussed by Bevensee (1973).

Inverse Scattering:

Continued interest in the inverse scattering problem was evidenced in this period. An idea of various approaches may be obtained from the contributions collected by Colin (1972).

Pertinent work has been done for the wave equation (Kalaba and Zagustin, 1974) (Weston, 1972,1974) (Weston and Krueger, 1973), the Helmholtz equation (Sleeman, 1973), low frequency approximations (Boerner and Ahoul-Atta, 1973) (Hill, 1973) (Van den berghe and Boerner, 1972a,b), and high frequency approximations (Hamid and Mohsen, 1972) (Van den berghe and Boerner, 1972c) and (Tabbara, 1973). Perry (1974) considered high frequency methods via regularization techniques which were also discussed by Deschamps and Cabayan (1972). The role of impedance boundary conditions in inverse scattering was studied by Boerner and Ahluwalia (1972) and applied in particular cases by Ahluwalia and Boerner (1973,1974), Chaplin and Aksel'rod (1972) and Chebyshev (1972). Some numerical problems were treated by Cabayan et al (1973). Related work was done on inversion of molecular scattering data (Buck, 1974), discrete methods (Case, 1973) (Case and Chiu, 1973) (Case and Kac, 1973), one dimensional profile inversion (Jordan and Kritikos, 1973), and logarithmic potential scattering (Parasyuk et al, 1972). The purported exact solution of Bojarski (1973) merits study to determine its validity, limitations and applicability.

Waveguide Scattering:

Included in the vast literature on waveguides during this period is the usual complement of waveguide scattering problems. Integral equation methods predominated this work which includes scattering in dielectric loaded waveguides (Bates et al, 1972),

periodic dielectric loadings (perng, 1972), stepped guides (Kazakova and Percikov, 1972), dielectric steps (Royer and Mittra, 1972), slotted guides (Khadzhinov, 1972), guides with circular sections (Lapta and Sologub, 1973) (Zhurav and Loser, 1973), cylindrical obstacles in rectangular guides (de Jong, 1972b), elliptical guides and obstacles (Gal and Khizhnyak, 1972) (Laura, 1972) (Ukrainets and Khizhnyak, 1973), and planar waveguides (Fel'd et al, 1973) (Il'inskii and Galishnikova, 1973) and (Nefedov and Fialkovsky, 1972).

Moving Boundaries:

Electrodynamics of moving media has been an area of increasing activity over the past decade and this trend continued during the period 1972-74. One class of problems involves scattering of waves by the moving boundary between two half spaces with differing constitutive parameters and work in this area was reported by Censor (1972a), Hosono (1974), Ostrovskii (1972), Solimeno (1974a,b) and Yasumoto (1972). Inhomogeneous moving media were treated by Aivazyun and Megelyan (1973) and Tanaka and Hazama (1972).

Scattering by moving obstacles in a stationary medium was studied with increasing intensity with specific consideration of moving half planes (Candel, 1973), plates (Krasilshchikova, 1972), mirrors (Ollendorff, 1972), strips (Hunter, 1972a), spheres (Bhartia, 1974), cylinders (Censor, 1972b) (LeVine, 1973), (Hunter, 1973a,b), arbitrary small obstacles (Nerukh and Khizhnyak, 1973) (Petrov, 1972a, 1973), and plasma columns (Shiozawa and Seikai, 1972a,b).

Rotating systems were discussed (Petrov, 1972b) (Shiozawa, 1973) as were radially expanding systems (Censor, 1973) (Pogorzelski, 1973). Scattering from oscillating irregular planes also received attention (Borker and Yang, 1973) (Konrady, 1974).

Scattering by Specific Geometric Configurations:

Most of the long standing favorite geometries have not been neglected in this period. New candidates have appeared as the exact solutions for scattering by a strip (Wolf, 1972, 1973) and the dielectric wedge (Lantz, 1973).

Other treatments of the strip and complementary slit problem were presented by Guiraud (1973a,b) and Pimenov and Press (1973). New approximate solutions have appeared for narrow strips and slits (Lebedev and Skal'skaya, 1972) (Leeb, 1972), medium slits (Lin, 1972), slits in thick screens (Deryck, 1973) (Roumiguires et al, 1973), slits in screens separating two media (Colombeau et al, 1973) (Facq and Robin, 1972) (Neerhoff and Mur, 1973), slits in an impedance plane (Hongo, 1972), slit formed by staggered parallel planes (Kashyap, 1974), and a rectangular groove in a metallic screen (Wirgin, 1973b).

Meixner (1972) examined the consequences of his edge condition at the edge of a dielectric wedge. Another edge condition study was made by Lang (1973b) at the common edge of a wedge and a resistive sheet. Scattering by dielectric loaded wedges was treated by Mohsen and Hamid (1973) and Towaij and Hamid (1974) while Bates (1973) considered both dielectric wedges and prisms.

Other problems involving cylindrical geometries which were reported included scattering from circular cylinders (Kosheroi and Mikhailovski, 1972), notched circular cylinders (Hunter, 1974), cylinders illuminated by Gaussian beams (Alexopoulis and Park, 1972), cylinders of varying cross section and constitutive material (Beloozerov and Dolgova, 1972) (Liou, 1972) (Maystre and Vincent, 1972) (Shafai, 1973b) (Shafai and Bhartia, 1973a,b) (Vasil'ev and Solodukhov, 1973) (Yeh and Wang, 1972), coated cylinders (Fedele, 1973) (Kovner, 1973) (Sveshnikov et al, 1972) (Uslenghi, 1973), cylinders near an impedance surface

(Bombardt, 1973) (Shcherbitskiy, 1972), elliptic cylinders (Alexopoulis et al, 1974) (Kaufman et al, 1973) (Van den Berg and Van Schaik, 1973), polygonal cylinders (Hunter, 1972b), hollow semi-infinite cylinders (Lee et al, 1973), hollow finite cylinders (Lebedev and Skal'skaya, 1973) and cylinders in a piezoelectric medium (de Jong, 1972c).

In addition to the work on the edge condition cited above in connection with wedge problems, a careful study of edge conditions was presented by Hayashi (1973) in his treatment of scattering from open surfaces, Fel'd (1973, 1974) and Ufimtsev (1974) also considered this problem. Radin and Shestopalov (1974) considered apertures on a sphere and Hunter and Bates (1972) examined small apertures (close edges) on perfect conductors. Edge diffraction in connection with scattering by a spherical cap was treated by Jain and Kanwal (1972) and a paraboloidal cap by James (1974), Rogers (1973a) and Watson and Ghobrial (1972).

The planar open surfaces, aperture in a plane screen and complementary disc, was the object of a number of scattering investigations. Half plane problems were treated by Hamid and Towaij (1972), Myshkin (1972) and Tan and Cheng (1972). Diffraction by arbitrarily shaped apertures was examined by Morita (1972) and thin plates were treated by Lin et al (1974) and Mittra et al (1973). Lit (1972) worked with the somewhat controversial boundary diffraction waves at the rim of an aperture and Tanaka et al (1972) studied aperture diffraction of beams. Scattering by a circular disc on the interface between different media received attention from Boersma (1972), Dmitriev et al (1973), and Lugovoi and Sologub (1973). A Babinet's Principle for a resistive aperture in a conducting screen was presented by Lang (1973a)

and criticized by Harrington and Mautz (1974). Scattering by a disc near an aperture was considered by Ivanov (1972) and Kuzmin (1972). Van Dueren (1972) analyzed scattering by a dielectric ring and Teague and Zitron (1972) treated an aperture between two wedges.

Other geometric shapes which were considered as scattering objects included the sphere (Inada, 1973) (Mandal, 1973), cone (Nikolaev, 1972), prolate spheroid (Gatkin et al, 1972), quarter plane (Satterwhite, 1974), straight line segment (Ranger, 1973, 1974), dielectric step (Mergelyan, 1972a), dielectric loaded corner reflector (Towaij et al, 1972), and V shaped wires (Lin, 1972). Shestopalov and Shcherbak (1972) treated obstacles which consisted of combinations of bodies for which the scattering properties were known. Ogawa and Fujioka (1972) examined scattering by the interface between two conducting media and Avetisyan (1972) treated dielectric bodies of revolution.

Multiple Scattering:

Two body scattering problems for spheres (Olaofe, 1974), spheroids (Van Buren and King, 1972), strips (Kanwal and Sacledeva, 1973), elliptical reflectors (Soejima and Shimada, 1973), discs (Marin, 1974b), and cylinders in an inhomogeneous medium (Pavlov, 1973a, b) all received attention during this period.

Twersky (1973) treated the three dimensional problem of a periodic line of identical obstacles and Leppington and Levine (1973) studied periodic apertures in a plane screen. Ramm (1974a, b) analyzed both scalar and electromagnetic scattering from collections of small bodies as did Peterson and Ström (1973, 1974a).

Two dimensional multiple scattering studies were carried out by Bezuglyi and Shestopalov (1972) for arrays of slotted circular cylinders, Howarth (1973)

Howarth and Pavlasek (1973) and Howarth et al (1974) for cylinders in a way which suppressed the single body scattering contribution, Kopaleishvili and Popovidi (1972a, b) for arbitrarily shaped cylinders at long wavelengths and Kyurkchan (1972) using an orthogonalization method to solve a system of integral equations for circular and elliptic cylinders.

Rough Surfaces:

Electromagnetic scattering by a rough surface was treated by O'Kelly and Kharadly (1972) while Bahar (1972a, b) considered rough impedance boundaries. The related acoustic problem for statistically rough surfaces was examined by De Santo (1974), Medwin and Hagy (1972), Welton (1973) and Zipfel (1974). Gardner (1973) considered backscattering at grazing incidence. Diffraction by a corrugated dielectric surface (Mergelyan, 1972b), a periodically corrugated surface (De Santo, 1973) and active corrugations (Lee, 1972) all received attention. Scattering by rough cylinders was also studied (Shah and Vardya, 1972) (Tong, 1974).

Inhomogeneities and Equivalent Boundary Conditions:

The effect of inhomogeneities, both in the constituent material of the scatterer and in the media in which the scatterer is immersed, has been the subject of a number of investigations. Spherically symmetric objects with radial inhomogeneities were examined by Semenov (1972) and Shafai (1972a), inhomogeneous shells by Alexopoulis (1972), and anisotropic as well as inhomogeneous objects by Okamata and Yamada (1973). Cylindrically symmetric objects were treated by Neelakantaswamy et al (1973) and Shafai (1972b).

Inhomogeneous media were considered by Foster and Anderson (1973b), Hassab (1972), Permitin (1973) and Tikhonov et al (1973). Attempts to approximate inhomogeneous media with equivalent boundary conditions were made for plane interfaces (Agranovich and Yudson, 1973) (Eaves, 1972) (Wegrowicz, 1972) and non planar grids (Kantorovich, 1972). Impedance boundary conditions were treated by Gudovich et al (1973) while Harrington and Mautz (1972b) studied reactive loading.

Selected Books:

A publishing event of importance is the long awaited appearance of the book on radiation and scattering by Felsen and Marcuvitz (1973). Another book that merits attention of the scattering community, especially but not exclusively concerned with numerical methods, was edited by Mittra (1973).

Other books deserving mention are the collection of papers on wave propagation edited by Babich (1972), Monteath's (1973) work on reciprocity, the time dependent problems considered by Nussenzweig (1972), Stavroudis' (1972) work on optics, Tolstoy's (1973) work on wave propagation and the study of black body scattering by Zakhar'yev and Lemanskiy (1972).

Finally, a review of scattering and diffraction for this period would be incomplete without mention of the publication of the extended abstracts of papers presented at the 1974 URSI Symposium on Electromagnetic Wave Theory (URSI, 1974).

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